IS 9001-9 (1981): Guidance for Environmental Testing, Part IX: Solderability and Resistance to Soldering Heat [LITD 1: Environmental Testing Procedure]

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(Reaffirmed 2003)

Indian Standard

GUIDANCE FOR ENVIRONMENTAL TESTING

PART IX SOLDERABILITY AND RESISTANCE TO SOLDERING HEAT

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GUIDANCE FOR ENVIRONMENTAL TESTING
PART IX SOLDERABILITY AND RESISTANCE TO SOLDERING HEAT

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Indian Standard
GUIDANCE FOR ENVIRONMENTAL TESTING
PART IX SOLDERABILITY AND RESISTANCE TO SOLDERING HEAT

0. FOREWORD

0.1 This Indian Standard (Part IX) was adopted by the Indian Standards Institution on 6 March 1981, after the draft finalized by the Environmental Testing Procedures Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard deals with the guidance details of solderability and resistance to soldering heat tests for electronic and electrical items. This standard shall be used in conjunction with IS : 9000 (Part XVIII)-1981* which deals with the soldering tests comprising:

a) Solderability of wire and tag terminations,

b) Resistance of items to soldering heat, and

c) Solderability of printed boards and metal-clad laminates.

0.3 While preparing this standard, assistance has been derived from the following:

IEC Pub 68-2-20 (1979) Basic environmental testing procedures, Part 2 : Tests, Test T : Soldering. International Electrotechnical Commission.

IEC Pub 68-2-44 (1979) Basic environmental testing procedures Part 2 : Tests, Tests-Guidance on Test T : Soldering. International Electrotechnical Commission.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Basic environmental testing procedures for electronic and electrical items : Part XVIII Solderability test.

†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard (Part IX) deals with the guidance for solderability and resistance to soldering heat tests which determine the ability of component terminations to wet easily and to check that the component itself will not be damaged by assembly soldering processes.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply in addition to those given in IS : 9000 (Part I)-1977*.

2.1 Colophony — A natural resin obtained as the residue after removal of turpentine from the oleo-resin of the pine tree, consisting mainly of abietic acid and related resin acids, the remainder being resin acid esters.

NOTE — 'Rosin' is a synonym for colophony, and is deprecated because of the common confusion with the generic term 'resin'.

2.2 Contact Angle

2.2.1 In general the angle enclosed between two planes, tangent to a liquid surface and a solid/liquid interface at their intersection (*see* Fig. 1). In particular the contact angle of liquid solder in contact with a solid metal surface.

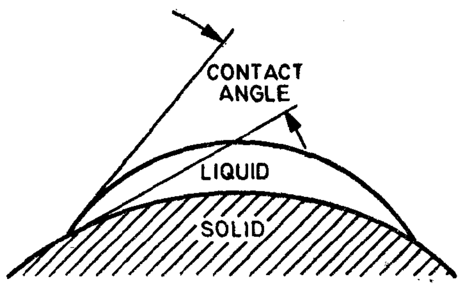

FIG. 1 CONTACT ANGLE

2.3 Wetting — The formation of an adherent coating of solder on a surface. A small contact angle is indicative of wetting.

2.4 Non-wetting — The inability to form an adherent coating of solder on a surface. In this case the contact angle is greater than 90°.

2.5 De-wetting — The retraction of molten solder on a solid area that it has initially wetted. In some cases an extremely thin film of solder may remain. As the solder retracts the contact angle increases.

*Basic environmental testing procedures for electronic and electrical items: Part I General.

2.6 Solderability — The property of a surface which allows it to be readily wetted by molten solder.

2.7 Soldering Time — The time required for a defined surface area to be wetted under specific conditions.

2.8 Resistance to Soldering Heat — The ability of an item to withstand the heating stresses produced by soldering.

3. GENERAL

3.1 The need has arisen for precise and objective methods of assessing the ability of component terminations to be soldered satisfactorily in times and temperatures suitably related to those employed in practice.

3.2 There is also a need for precise methods of subjecting components to such thermal stresses as would occur in soldering, prior to testing the components for damage which could be attributed to these thermal stresses.

3.3 Both checks are necessary. They may be carried out in separate series of tests on different components.

3.4 To be realistic, all such tests shall depend on the application under controlled conditions of specified solders and fluxes to the items under test. It is preferable to have tests the results of which are quantitative, and leave it to the relevant specification writer to state which values of those quantities are acceptable. This ideal has been only partially achieved in soldering test, and where qualitative assessments have been described, their limitations should be borne in mind. For qualitative assessments, the employment of experienced operators is advisable.

3.5 It shall be emphasized that there may be no direct and simple correlation between the results of the various solderability and thermal stress tests that is valid for all types of components, nor may these tests match all the varieties of production conditions exactly. It is the task of the relevant specification writer to correlate test results with the desired performance for each component and specify acceptance levels accordingly.

3.6 The plan given in Fig. 2 shows the arrangement of the various parts/sections and methods which comprise solderability and resistance to soldering heat tests of IS : 9000 (Part XVIII)-1981*.

4. SOLDERABILITY

4.1 General Considerations

4.1.1 A soldered joint between two or more workpieces is made by allowing molten soft solder, aided by a flux, to flow into the space between the

*Basic environmental testing procedures for electronic and electrical items: **Part XVIII** Solderability test.

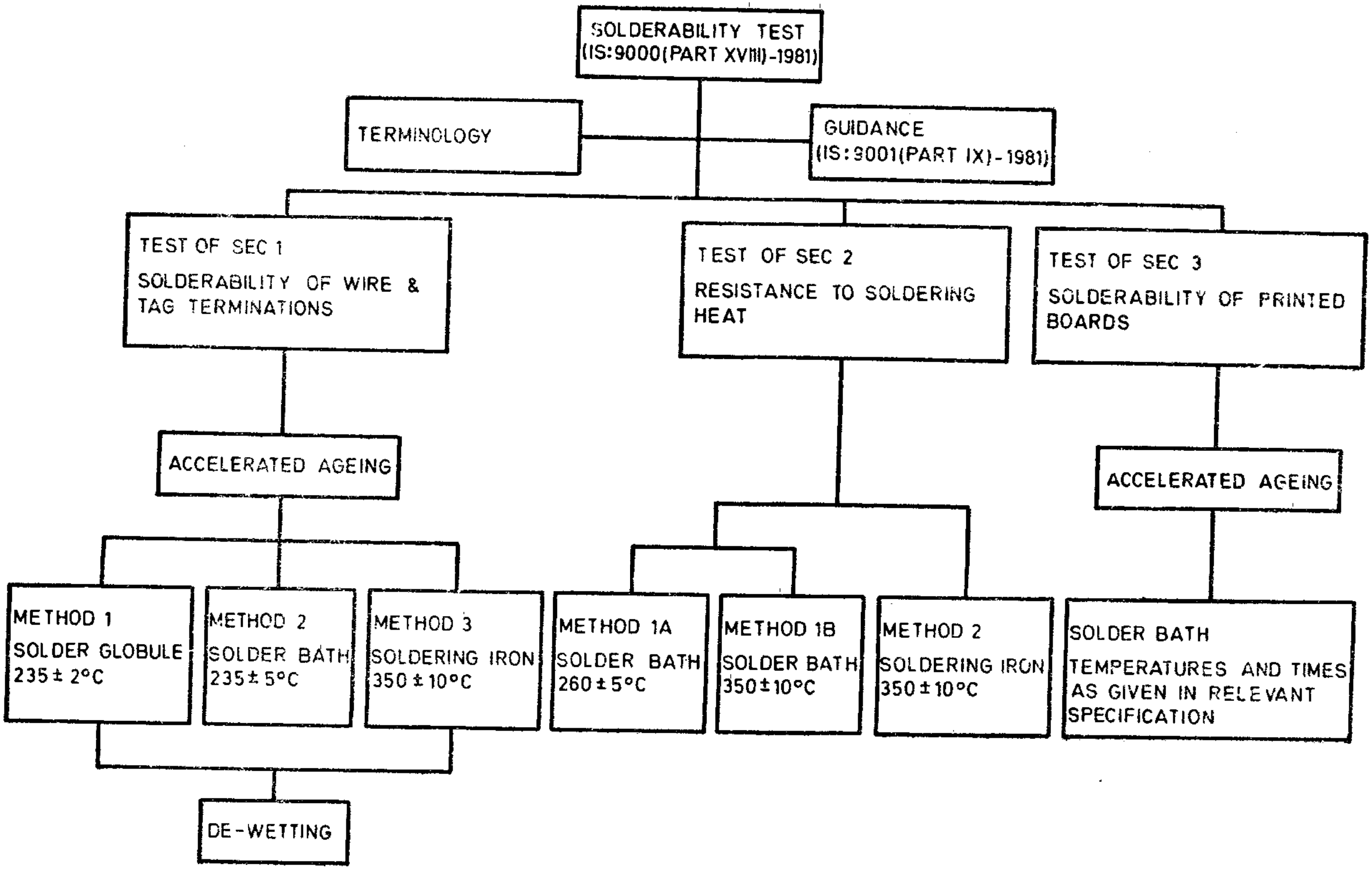

FIG. 2 ARRANGEMENT OF SOLDERABILITY TEST

workpiece surfaces which permits the formation of a good bond with a specified soft solder alloy in the presence of a specified flux and at a specified temperature.

4.1.2 The word 'solderability' is commonly used in two senses, both of which are covered by the definition just given. First, it may mean the ability to allow formation of a joint between two workpiece surfaces. This property is described here as 'joint quality' and methods for measuring it are mentioned in **6**; it depends on choices made at the design stage. Second, it may mean the time needed for such a joint to be formed. This property is described here as 'soldering time'. It is usually measured in terms of the time required to achieve a desired degree of wetting under specified conditions.

4.1.3 Soldering time measurements can only be made on surfaces on which the increase in temperature is unlikely to give rise to side effects liable to make the measurements lose all significance. In particular, the soldering time of plated metals can only be measured if the plating adheres to the base metal. The means of detecting adhesion faults are enumerated in **6**.

4.2 Choice of Solder — Because most soldered joints in electrical and electronic equipment are made using solder containing nominally 60 percent tin and 40 percent lead, this alloy has been chosen for all tests. Experience has shown that impurities up to the maximum listed in Appendix A do not affect the wetting power of this alloy.

4.3 Choice of Flux

4.3.1 The majority of soldered joints in electrical and electronic equipment are made using a flux consisting of colophony (modified or natural), usually with additions of activators which improve the wetting power of the molten flux or increase the rate at which it dissolves metal oxides. Activated fluxes may produce very short soldering times. They are generally proprietary materials of unrevealed composition. In order to avoid difficulties in specifying soldering times for each type of activated flux and to include the worst conditions, it is preferable to use natural inactivated colophony as the flux for the solderability test so that the durations are easily measurable. In cases where this would be unrealistic or impracticable, the use of specified activated fluxes for testing is permitted.

NOTE — When activated flux is used, it should be ensured that the activator has not been evaporated before use.

4.3.2 It shall be stressed that the presence of an activated flux in the solderability specification shall not be taken to imply its suitability for production use, nor the guarantee that its residues are free from corrosive tendencies. Reference should be made to the available specifications for activated fluxes when choosing fluxes for production soldering.

4.3.3 The flux is most conveniently applied as a solution of colophony in 2-propanol or ethyl alcohol. It has been found that variation of

concentration in the range 25 percent to 40 percent by weight of colophony has no effect on the soldering time as measured by the globule test. A concentration of 25 percent by weight was therefore chosen as the standard in order that increase in concentration due to solvent evaporation should not affect results. The specifications for the flux constituents which shall be used are given in Appendix B.

Caution Note — In case ethyl alcohol is used, it shall be tested to comply with the requirements of **B-3** before usage.

4.4 Temperature of Test

4.4.1 Soldering temperature in practice is defined as the temperature of the workpiece surface during the soldering operation. As the temperature is difficult to observe and depends very much on the relation between the heat capacity of the workpiece and the heating power of the soldering device, the temperature of the test is defined as the temperature of the unloaded solderability test instrument before application of the item under test.

Different test temperatures are used in order to simulate practical soldering conditions. The temperature of 350°C is chosen when the solder bath and the solder globule method are not practicable and to simulate the use of high temperature soldering irons often used for repair work and for the soldering of self-fluxing enamelled wires. A lower temperature is needed to simulate production work using solder baths or controlled soldering irons. Though such work is frequently done at 250°C, a temperature of 235°C is chosen for solderability testing, because, at 250°C, the soldering time of good wires is too short for accurate measurement. The time is increased and the test thereby made more discriminating by operating at lower temperature, provided of course that under load the temperature does not fall too close to the liquidus temperature of the solder.

4.5 Ageing

4.5.1 The solderability of a workpiece may deteriorate considerably with time. It is, therefore, necessary to have a procedure whereby this ageing may be artificially accelerated, in order to know in advance how the workpiece will behave after prolonged storage. The ageing process may be due to the environmental conditions during storage, or to inherent qualities of the workpiece itself.

4.5.2 It shall be appreciated that the effects of natural ageing are highly variable and depend on the local environment. It is, therefore, not possible to provide an 'accelerated natural ageing' procedure. It is, however, possible to provide procedures which produce standard amounts of ageing, caused by air, moisture and metallic diffusion. The relation between these amounts of ageing and that amount which would occur naturally in any particular environment can only be stated very approximately.

4.5.3 The ageing procedures specified are intended to accelerate the effects of atmospheric oxygen, moisture, and the inherent ageing tendencies of the workpiece only. They are not intended to simulate the effects of industrial atmospheric pollution.

4.5.4 Accelerated ageing should be used only when it is required to test for the retention of good solderability after a period of natural ageing. It should not normally be used when the test is part of a sequence of tests.

NOTE — It is recommended to carry out accelerated ageing tests on those items which are likely to undergo storage before use.

5. METHODS FOR SOLDERABILITY TESTS

5.1 Choice of Method

5.1.1 The solder globule test is intended for determining the soldering time of round wire terminations. The solder bath and soldering iron methods are for use:

a) where the shape of the component or its termination precludes the use of the globule method, for example, as with tag-ended components or printed circuit boards; or

b) where the soldering temperature required is outside the range of the globule test instrument, for example, as with polyurethane enamelled wires.

5.1.2 It should be noted that soldering speed usually increases with rising temperature, therefore, terminations tested at 235°C usually have a shorter soldering time at higher temperatures.

5.1.3 The specification writer should ensure that any component test sequence, for example, for type testing, is arranged so that:

a) no previous soldering has taken place, for example, to make initial measurements;

b) no prior treatment, liable to affect the solderability (for example, preconditioning at elevated temperatures) has taken place (*see* **4.5**). Therefore the solderability test should be fairly close to the beginning of the test sequence; and

c) the finish of the termination has not been damaged in any previous test.

5.1.4 The following general precautions apply to all methods of solderability testing:

a) The tests shall be carried out in a draught-free place, and

b) To avoid contamination of the item through handling, the use of tweezers is recommended. If the item requires straightening, it shall be done in such a manner that the surface is neither scraped nor contaminated.

5.2 Solder Globule Test

5.2.1 Samples of the wire to be tested are fluxed and then placed in a globule of molten solder so that the globule is bisected by the wire. The time taken for the globule halves to flow over the wire and unite above it is the soldering time.

5.2.2 The relation between wire size and globule height has been chosen so that the reunion of the globule above the wire cannot occur without wetting. The globule height is controlled by using pre-weighed pellets of solder, deposited on iron pin and retained by a surrounding surface of (non-wettable) aluminium. The aluminium also helps to stabilize the temperature of the iron pin.

5.2.3 The top surface of the iron pin shall be tinned. After completion of the testing, the heating block should be allowed to cool with a solder pellet in position to prevent oxidation of the iron pin and subsequent de-wetting.

5.2.4 In cases of dispute, it may be necessary to ensure that all pellets used for testing are within the limits of ± 10 percent of the nominal pellet weight.

5.2.5 The following are general hints on the use of the globule apparatus:

a) The iron pin shall be quite clean, with no fragments of solder between the aluminium block and the horizontal panel, as this may affect the temperature.

b) The flux shall be of the correct type and shall not be tacky through evaporation. The amount of flux applied shall be carefully controlled because superfluous flux causes a further reduction in temperature.

c) Each molten globule shall be clean and bright and the size of the pellet used shall be correct for the nominal diameter of the termination.

d) The termination shall accurately bisect the globule. If it does not do so the result should be disregarded and another attempt made further along the termination.

5.2.6 For wires of equal soldering quality, the observed soldering time will increase with increasing wire diameter. The test is somewhat sensitive to temperature, and results will therefore vary with the thermal characteristics of the component termination, which influence the effective soldering temperature. These factors of course apply equally to production soldering, but they should be taken into account when preparing component specifications. It shall also be remembered that activated fluxes giving much shorter soldering times are normally employed in production soldering.

5.2.7 The test is quick, quantitative and discriminating; it permits the determination of solderability at a number of points on the termination if the need arises.

5.3 Solder Bath Test

5.3.1 There are two versions of this test, one for wire and tag terminations and the other for printed boards. Both employ the same form of solder bath. When an item is immersed, the solder temperature falls close to the point of immersion, but the bath specified is of sufficient size to ensure that the temperature of the solder does not fall significantly during the immersion period.

5.3.2 The solderability procedure given in Method 2 of Sec 1 of IS : 9000 (Part XVIII)-1981* is intentionally kept simple to make it as versatile as possible. The method is mainly intended for the testing of termination, other than round wires, which are intended to be soldered in a solder bath.

5.3.3 For printed boards [*see* Sec 3 of IS : 9000 (Part XVIII)-1981*] the depth of immersion of the board is strictly limited to ensure that flow of solder up plated through holes can only be caused by wetting and not by Archimedean forces.

5.4 Soldering Iron Test — This test is retained to permit an assessment of solderability to be made on such items as cannot be tested by the globule or bath methods. Typical cases would be self-fluxing enamelled wires, where the temperature of the other methods is too low; and tag-ended components not intended for dip-soldering where it may not be possible to apply solder in any other way than with a soldering iron.

6. SOLDERABILITY AND DE-WETTING PHENOMENA

6.1 Owing to the variety of shapes and sizes of component terminations, solderability tests alone cannot predict the strength of a joint. It is, therefore, suggested that item circuit assemblies be prepared and subjected to mechanical tests such as impact or vibration.

6.2 In suitable circumstances the contact angle between the solder and the item may give information on the joint quality.

6.3 Fundamentally, soldering time tests are estimates of the time required for the contact angle to fall to a uniformly low value at all points on the solder boundary. However, if the item is allowed to remain in contact with molten solder, the contact angle may increase again. This phenomenon is known as de-wetting, and is due either to the solder forming a non-wettable

*Basic environmental testing procedures for electronic and electrical items: Part XVIII Solderability test.

intermetallic compound layer on the item, or to the solder dissolving the plating to uncover a non-wettable substrate surface. Where this possibility is suspected, the relevant specification should require the de-wetting test to be applied.

7. RESISTANCE TO SOLDERING HEAT

7.1 It is an advantage to use an activated flux for this test in order to give rapid wetting and so ensure that the rate of heat input to the item under test is, so far as possible, independent of its solderability.

7.2 The remarks in **4.2** and **4.4** regarding choice of solder and consideration of temperature in solderability tests apply equally to testing for resistance to soldering heat. It is particularly important that, when testing items of large heat capacity, the equilibrium temperature does not fall below 40°C above the solder liquidus temperature. Equilibrium is not necessarily reached during the 5 s or 10 s immersion specified in **6.3.3** of Sec 2 of IS : 9000 (Part XVIII)-1981*, but since the position of equilibrium is related to the rate of heat input before equilibrium is reached, the above consideration still applies. The solder bath specified in Method 2 of Sec 1 of IS : 9000 (Part XVIII)-1981* is of sufficient size to ensure that the temperature is adequately maintained.

7.3 This test is not intended to simulate or assess the effect of incidental mechanical stresses which may be imposed while soldering. The test is potentially damaging or destructive to the item under test and consideration shall be given to this point when deciding the sequence of environmental testing.

APPENDIX A

(*Clause* 4.2)

SPECIFICATION FOR SOLDER

A-0. GENERAL

A-0.1 The solder used shall comply with grade Sn 60 of IS : 193-1977† or grade 60 of IS : 1921-1975‡, the following summarises the basic properties of such solders.

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*Basic environmental testing procedures for electronic and electrical items : Part XVIII Solderability test.

†Specification for soft solder (*third revision*).

‡Specification for rosin-cored solder wire (*first revision*).

A-1. CHEMICAL COMPOSITION

A-1.1 The composition by weight shall be as follows:

Tin	59 to 61 percent
Antimony	0·5 percent, *Max*
Copper	0·1 percent, *Max*
Arsenic	0·05 percent, *Max*
Iron	0·02 percent, *Max*
Lead	the remainder

A-1.2 The solder shall not contain impurities such as aluminium, zinc, or cadmium in amounts which will adversely affect the properties of the solder.

A-2. MELTING TEMPERATURE RANGE

A-2.1 The melting temperature range of the 60 percent solder is as follows:

Completely solid	183°C
Completely liquid	188°C

A-3. SOLDER PELLET WEIGHT FOR GLOBULE TEST

A-3.1 Not more than 1·5 percent of the pellets shall be outside ± 10 percent of the nominal mass.

APPENDIX B

(*Clause* 4.3.3)

SPECIFICATION FOR FLUX CONSTITUENTS

B-1. COLOPHONY (*see* IS : 553-1969*)

B-1.1 Composition and Properties

Colour	To WW colour specification or paler
Acid value (mg KOH/g colophony)	155, *Min*
Softening point (ball and ring)	70°C, *Min*
Flow point (Ubbelohde)	76°C, *Min*
Ash	0·05 percent, *Max*

*Specification for rosin (gum rosin) (*first revision*).

Solubility	A solution of the colophony in an equal part by weight of 2-propanol (isopropanol) shall be clear, and after a week at room temperature there shall be no sign of a deposit

B-2. 2-PROPANOL (ISOPROPANOL) (*see* IS : 2631-1976*)

B-2.1 Composition

Purity	99·5 percent 2-propanol (isopropanol) by weight, *Min*
Acidity as acetic acid (other than carbon dioxide)	0·002 percent by weight, *Max*
Non-volatile matter	2 mg per 100 ml, *Max*

B-3. ETHYL ALCOHOL (*see* IS : 324-1959†)

B-3.1 Composition

Purity	96·2 percent ethyl alcohol by weight, *Min*
Free acids (other than carbon dioxide)	4 mg/l, *Max*

NOTE — When an activated flux is called for, this may be conveniently made up as follows:

Colophony	25 g	for 0·5 percent chloride activation
2-propanol (isopropanol) or ethyl alcohol	75 g	
Diethylammonium chloride	0·39 g	

*Specification for isopropyl alcohol (*first revision*).

†Specification for ordinary denatured spirit (*revised*).